EFFECTS OF ANTHROPOGENOUS MORPHOLOGICAL CHANGES TO THE BED STABILITY OF THE DANUBE RIVER

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1. Introduction

The Danube to the east of Vienna – as other rivers in Europe – is suffering from river bed erosion for a long time, which has negative effects on ecology, water balance and navigation as well. To improve the situation a major rehabilitation project is planned for the approx. 48 km long river reach to stabilize the river bed.

This project comprises measures like the regulation of the low water level, renaturation of the artificially constructed river banks and creation of a network of waters by connecting oxbow lakes and distributaries of the Danube river, but the most significant one is the granulometric bed improvement (GBI) by coarsening the bed material for the stabilisation of the river bed. The objective is to dynamically stabilize the river bed and to reduce the present bedload transport capacity by about 90% in adding an approx. 25 cm thick layer of grain sizes (40/80 mm) within the grading curve of the river (0/100 mm).

Fig. 1: River bed with application of gravel-layer (granulometric bed improvement - GBI), model scale 1:10

To investigate the behavior of the added material and to find out the influence of local turbulence production on river bed stability hydraulic model tests were conducted.

2. Experimental Investigations

2.1 Section model tests

The aim of the section model tests carried out in a 2 m wide flume (scale 1:10) with a discharge up to 2,500 l/sec (790 m³/s in nature) was to verify, if the 25 cm layer of coarse gravel (grading curve 40/80 mm) withstands the local bed shear stress of 40-45 N/m² at the highest navigable water level and thus significantly reduces the erosion process [1].

Fig. 2: Total view of the section model scale 1:10, view upstream
2.2 **Full model tests**

In order to find out the influence of local man-made structures in the river bed, the results of the flume experiments were verified in full-model tests (scale 1:33.33).

**Fig. 3:** Sieve curves in full model

In one experiment a special groyne-like structure was used to divide the mean flow in two reaches (main channel for navigation and an ecological streambed). With this artificial structure a decreased stability of the GBI in the whole area downstream of the groyne was observed. Reason for that was the increased turbulence in the flow, produced by the groyne.

**Fig. 4:** Total view of the full model scale 1:33.33, view downstream

Numerical 2d-simulations show only a minor increased bed shear stress downstream of the groyne (Fig. 6).

**Fig. 5:** River bed change $z$ in meters, without and with groyne from physical model, scale 1:33.33, after 23 days with 4817 m$^3$/s

**Fig. 6:** Load on the river bed (Shields value divided by critical Shields value), without and with groyne, from a 2d-numerical simulation.

3.**Results**

The experiments showed that local measures do not only have local influence on bed stability like scours or bars. Locally produced turbulence is added to the regular turbulence and is transported downstream, which can influence incipient motion of particles and armour layer development on large areas of the river bed significantly.

4.**References**